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13. ABSTRACT (Maximum 200 words)

"Analysis and Assessment of Military and Non-Military Impacts on Biodiversity:A Framework for Environmental Management on DoD Lands Using the Mojave Desert as a Regional Case Study" designed and modeled alternative futures (patterns of land use as they might exist in the year 2020) in order to assess the projected status of biodiversity in the Mojave Desert.

The project's objective was to provide assistance to DoD allowing them to engage in proactive ecosystem management within the California Mojave Desert by providing projections on changing patterns of land use which might occur by 2020 and to assess the impacts of the future scenarios on the viability of a number of focal faunal species. The set of alternative futures was based on assumptions derived from biophysical, economic, and socio-demographic drivers.

While approximately 33 alternative futures (and permutations) were developed in the study, only nine were evaluated against the 11 focal species. Results show that all of the futures have essentially the same impact on habitat loss with some affecting some species more than others. The habitat most threatened is the sand and gravel-dominated habitat of shich over 66% occurs on private land and is highly threatened by development. Three species are particularly threatened on this habitat. We recommend that DoD be concerned over the potential loss of this habitat and take a proactive role in management by assisting the BLM in its management of this type.

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The primary objective of this research was to provide DoD with techniques, tools, and training to carry out its military mission in the context of regional management of biodiversity and related ecological, stakeholder, as well as cultural and environmental resource concerns. The project addressed environmental problems at the regional scale in the western Mojave Desert. It analyzed the impacts of potential patterns of land use (alternative futures) as they might occur in 2020 on

patterns of biodiversity and related environmental resources. A strategic goal of the project is to enable the entire set of western Mojave installations to manage their resources unilaterally within the context of the region as a single entity as opposed to independent management without the benefit of their unity. While the project is oriented toward the installations which occur in the Mojave, it may be desirable to the military for other regional stakeholders to have access to the techniques developed. This report summarizes the approach and methodologies used and developed and management recommendations to the DoD of this effort.

In previous years, the research team from Desert Research Institute, Oregon State University, the Forest Service, Utah State University, and San Diego State University prepared the underpinnings for the effort to design, model, and evaluate the alternative futures for the Mojave Desert. This has been summarized previously (in annual reports to SERDP and to the ARO). This effort involved determining the extent of urbanization, and change in urbanization from 1970 to 1990 trhough remote sensing-derived change detection, defining habitat characteristics in terms of terrain (the "LizLand Model"), selection of species for the evaluation, defining the habitat relationships for those species using the LizLand Model, and isolating those factors which would help to explain why development occurred where it did between 1970 and 1990. The team noted variables that reflect a number of factors associated with regional patterns of development: distance to existing development, percentage of surrounding development, distance to primary roads, location within city limits, distance to secondary roads, and slope percentage. The values of those variables were associated with each of the study regions 1.5 million grid cells. Using a model developed by one of the Utah State researchers (Manuel Gonzales) for his dissertation, a probability surface was generated for each of the undeveloped grid cells. That probability surface became the mechanism for creating the alternative futures.

Three separate categories of scenarios have been defined. The first of these takes existing trends and extrapolates them into the future using reasonable assumptions in conjunction with existing models. These are "model-based" scenarios. The second class of scenarios combines the same approach used for the model-based scenarios with newly based spatial information which that simulates the effects of land use plans land use policies, or new construction. These are "planning" or "design-based" scenarios. The third category combines the output from model-based and planning-based scenarios to create a scenario that reflects the interactions between the individual scenarios. These are "combinatorial scenarios".

Two of the most basic model-based scenarios are "trend" and "buildout". The trend scenario addresses the question: "what will the Mojave look like in the year 2020 if current development trends continue? The resultant scenario was simulated by distributing the projected population increase of 877,000 people onto the probability surface discussed previously. The resultant increase expands the urbanized area by 363,000 hectares. The "buildout" scenario depicts the Mojave at an undetermined time in the future in which every developable parcel is built upon. It is against these two scenarios that the others are evaluated. The alternative scenarios typically have four permutations: scenario at the current projected population increase, the scenario at 50% greater than the forecasted population increase; the scenario projected at 3.76 people per hectare (the current density on developed lands), and the scenario projected at 20 people per hectare.

The following scenarios were developed:

1. New Roads -- several hypothetical roads were added to he primary roads coverage, then by using the development probability model (partly as a function of access to primary roads), development is projected.
2. New City -- A newly incorporated city was added to the growth model
3. Exchange 1 -- swap private land with low development probability but with high biodiversity value for public land with high development probability but low biodiversity value.
4. Exchange 2 -- Establish a 5 km buffer around the four large military installations. Private land occurring within this buffer is converted to public land. BLM land occurring within 8 km of urban areas is converted to private land for the swap.
5. Exchange 3 -- Swap all inholdings of private land within Status 1 Lands (i.e., Parks, wilderness areas) with public lands having a high probability of development and near existing development.
6. Exchange 4 -- Establish a 16 km buffer around flight paths within the R-2508 Complex Environmental Baseline Study and exchange private lands falling within the buffer for a comparable amount of public land falling outside the buffer.
7. Combinatorial -- combines trend, New City, Urban encroachment buffer and inholding consolidation (exch 3).
8. Trend

As each of these scenarios have permutations, the total number of alternatives is 33 (includes buildout).

A new model of reptile habitat for the California Mojave Desert based upon macro and micro landform characteristics was developed, the LizLand model. Liz-Land is a spatially explicit habitat model that defines and predicts reptile habitat in arid environments based upon the regional macro landform scale, its micro land-form characterization and the relationship of reptiles to these characterizations.

The existing state-of-the-art in habitat modeling in the California Mojave Desert is the combined work of the California GAP Program (Davis et al., 1998) and the California Wildlife Habitat Relationships System (CWHR) (Airola, 1988). Along with distribution maps the CWHR describes the management status, life history and habitat requirements of California's wildlife species. The USGS National GAP Program (Scott et al., 1993) produced species habitat maps for most mammals (except bats), birds, amphibians and reptiles across much of North America, including those found in the California Mojave Desert. Both the National GAP Program and the CWHR were built upon one of the most successful and widely used means of defining species habitat relationships: the categorization of the land-scape into land cover classes, namely vegetation classes. Conceptually, LizLand is centered around geomorphic landforms, but also considers the contribution of vegetation composition and structure to each species. At present a reliable, accurate, and consistent spatial representation of Mojave Desert wide vegetation does not exist. As a result, the LizLand GIS model is based solely upon the characterization of the

macro landform and its link to reptile habitat. When an adequate map of Mojave Desert vegetation becomes available, it can be incorporated into the model as needed. By focusing the characterization of habitat on geomorphic landforms instead of vegetation we address the unique biological requirements of desert reptiles, and by linking large scale macro land-forms to reptile habitat via micro landform characterizations we address the issue of management scale and ecosystem research as discussed by Heaton & Keister (in review).

As a result of the integration across both spatial and managerial scales, LizLand provides species presence/absence information that is sufficiently precise and robust enough to provide useful data to land managers for the five species presented here. At broad spatial scales, LizLand models the unique macro landform characteristics of the California Mojave Desert. Reptile habitat preferences were linked to these macro landforms via their mutual micro landform characterizations. Future managerial decisions could be based upon information from both broad (macro landforms) or local scales (micro landforms), or some combination of the two.

Each of the scenarios has been evaluated against habitat to determine relative impact on habitat and against the following eleven species to determine relative impact on those species:

Scientific name	Common name
Gopherus agassizii	Desert tortoise
Sauromalus ater	Chuckwalla
Callisaurus draconoides	Zebra tailed lizard
Uma scoparia	Mojave fringe toed lizard
Crotophytus bicinctores	Black collared lizard
Uta stansburiana	Side blotched lizard
Cnemidophorus tigris	Western whiptail
Toxostoma bendirei	Bendire's thrasher
Toxostoma lecontei	Le Conte's thrasher
Spermophilus mojavensis	Mojave ground squirrel
Dipodomys panamintinus	Panamint kangaroo rat

All of the scenarios have remarkably similar impacts on habitat and species. It is clear that some habitats which have a higher occurrence in the more developed western Mojave will be impacted more than will habitats occurring in the areas of higher federal controla nd management. Indeed, the windblown sand habitats are predicted to lose more than 25% of their areal extent due to projected development patterns. Species most threatened on the sandy habitats include Dipodomys panamintinus (Panamint kangaroo rat), Spermophilus mohavensis (Mojave ground squirrel), and Uma scoparia (Mojave fringe-toed lizard).

Summary and Conclusions

Development pressures nationwide are increasingly impacting both established land uses and the ability of natural lands to provide various environmental services and amenities. In the California Mojave Desert, these pressures are becoming increasingly important for several reasons. First, the region's diverse physiographic features makes it ecologically significant in many ways. Included are high levels of endemic species, and a growing number of high visibility species that are considered threatened or endangered, or are likely to attain such status under current trends. The California Mojave Desert's importance for military training is perhaps unrivaled by any other region of the country. These ecological and traditional land uses are increasingly threatened by the rapid pace of past and projected human population growth in the California Mojave Desert.

This study developed an approach to generate and assess alternative future development options for the region. The alternative futures are spatially-explicit and allow for the interrogation of the landscape at various scales. The approach is flexible and is intended to be readily applied by various stakeholders in a user-friendly fashion. It can be used to generate an endless number of potential future scenarios in order to allow stakeholders the ability to both investigate future land use options, and determine their likely impacts on a wide range of relevant criteria.

The scenarios presented explore a number of issues raised by stakeholders during the study. These scenarios fall into two broad categories: (1) the likely trend of future development under past development policies and patterns, and (2) various alternatives to the trend that meet specific stakeholder interests and concerns. The scenarios illustrate the power of the approach. For example, the wide range of scenarios explored-urban encroachment buffers, infrastructure upgrades and enhancement, ecologically-based restrictions on development, and public/private land exchanges. All demonstrate the ability of the approach to both adapt to a wide range of issues, and provide policy-relevant information to various publics and the military.

This report should be viewed as an introduction and brief demonstration of the approach's application and utility. The scenarios and assessments described in this report provide a first look at the important issues facing the California Mojave Desert region and its inhabitants. Key areas of concern identified include conflicts between likely future development and the region's sensitive ecological species, and the impact of development on military installations and their ability to meet their respective military missions.

Three general conclusions emerge:

1. Biodiversity preservation options on privately held lands in the Mojave are extremely limited. Other than Plans build-out, all of the alternative futures produced essentially the same output, which afforded very little land that could be used to protect biodiversity. The majority of private land is in the western Mojave and this area will become fully developed relatively soon with the probably exception of mountainous areas. So the preservation of biodiversity in the Mojave is almost entirely in the hands of the federal agencies, including the military, which have extensive holdings there. This is especially true of Edwards Air Force Base.

2. Our studies of the habitat relations of the focal species and to some extent all vertebrate species in the Mojave show a strong relationship between most species and large-scale geomorphology. Most of the habitats are well protected by the federal land management agencies in the Mojave (DoD and DOI, primarily) with the exception of the sand and gravel–dominated habitats. Only 5% of its areal extent is protected in the BLM wilderness areas, less than 15% is protected by other BLM and the Park Service. 14% occurs in military lands, leaving over 66% unprotected. This lack of protection is not surprising considering the fact that this type has been most favored by human settlement.

3. With regard to options available to the military to proactively protect biodiversity, it should recognize the potential importance of these threatened (and valuable to biodiversity) habitats. Perhaps the military should work more closely with the BLM, assisting it in the management of its areas in order to protect the threatened habitats and thereby protecting itself (i.e., the DoD) from future problems related to its own and important land uses.

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